

THE FORE LEG AND PECTORAL GIRDLE OF MOROSAURUS.

BY E. S. RIGGS.

The genus *Morosaurus** Marsh, is based upon a sacrum offering for its primary distinguishing character the presence of four coössified centra. Other distinguishing characteristics are the massiveness of the anterior portion of the skull and mandible, the expansion of the upper end of the scapula, the broad blade of the ischium and the posterior direction of its distal end. The sutural articulation of the neural arch with the centrum in the vertebræ is not significant but dependent upon age.

Marsh has proposed five species under this genus: *M. grandis*, *M. impar*, *M. robustus*, *M. latus* and *M. agilis*. Of these species he offers but few distinctive characteristics and in his monograph makes no attempt to distinguish them. *M. impar* was the type of the genus, but, as Williston has already pointed out,† it is clearly a synonym of *M. grandis* earlier described as *Apatosaurus grandis*. While the specimen upon which the former species was based must remain the generic type, that of the latter being much more complete and better known will naturally be referred to in comparisons. *M. robustus* is based upon a lone ilium larger than the last, but otherwise difficult to identify. *M. latus* is not to be distinguished by the sutural articulation between the centrum and the neural arch of the vertebræ as Marsh's figures would suggest, but by the massiveness of all parts of the skeleton and the depression of the vertebral pedicles so that the neural arch rests directly upon the centrum. The suture is noticeable in young specimens of other species and evidently disappears in the adult. *M. agilis*, in direct contrast with the last named species, is characterized by the lightness and slenderness of its skeleton and by its very small size. In the hind foot the first digit is massive while the other four are unusually slender.

The genus *Morosaurus* is represented in the collections of this Museum by a nearly complete fore leg with coraco-scapula, two other

*American Journal of Science, 3d ser. Vol. XV, p. 242.

†Kan. Univ. Quarterly, Vol. VII, p. 173.

coraco-scapulæ, an incomplete fore foot, a disarticulated sacrum, an ilium, a tibia and various dorsal and caudal vertebræ, together with a fine series of cervical and dorsal vertebræ not yet removed from the matrix.

An almost complete fore leg (Plate XL), collected by the Museum expedition of 1900 near Fruita, Colorado, shows some interesting characteristics not hitherto pointed out. The specimen was found in the uppermost stratum of the green shale which represents the lower Como Beds in this locality.* Its dimensions are a little greater than those of *M. grandis*, Marsh, but the proportions are so nearly the same that it seems desirable to refer it to that species. The entire specimen save the foot bones had been weathered out of the matrix and certain parts lost entirely, but its chalcedony filling had preserved the fragments so well that the whole has been restored with approximate accuracy.

The chief point of interest is in the foot-structure which does not agree with the mesaxonic theory of the structure of the front foot in Sauropoda as advanced by Osborn.* On the contrary the first digit in this specimen bears a stout claw which is directed inward and shows evidence of having been semi-opposable. A second specimen belonging to a smaller species has a similar structure.

Of the carpal bones only the radiale is preserved in this specimen (Pl. XLI, Fig. 1). Metacarpal I is not so stout in proportion as that of *Brontosaurus*, but is stronger and noticeably shorter than the succeeding members of the series. Its proximal end presents to the radiale a broad ovoid surface with the long diameter directed meso-anteriorly. The shaft is twisted so that the axis of the distal end is rotated inward. Its articular surface for the first phalanx slopes upward and backward from the anterior to the postero-internal border. Phalanx 1 of this digit is short and prismatic, articulating closely with the carpal as well as with the stout ungual which it bears. The digit as a whole is thus directed mesially with the ungual inclined backward, and as before stated was probably semi-opposable.

Metacarpal II is longer but almost as stout as the first. Its proximal end is broadest meso-laterally while the axis of the distal end is rotated slightly toward the mesial side. Phalanx 1 is very unlike its homologue of the first digit. It is flattened vertically and articulates with the metacarpal by an almost plane surface, while the distal facet is convex and flanked on either side by rugosities for liga-

*Riggs, Dinosaur Beds of the Grand River Valley of Colorado, Pubs. Field Columbian Museum, Geological series, Vol. I, No. 9.

†Bulletin of the American Museum, Vol. XII, p. 168.

mentary attachment. Phalanx 2 is similar in form but smaller and less roughened. The ungual is wanting. Metacarpal III is represented by its distal third only. Metacarpal IV has a constricted proximal end and is more slender in the shaft than Metacarpal V. The latter has a conspicuous process for ligamentary attachment on the posterior angle of its proximal end. A doubtful phalanx, identical in structure with that placed upon Digit I in Am. Mus. No. 332 (*loc. cit.*) has been provisionally referred to Digit V. Its rounded distal end with no trace of articulating surface indicates that it was surmounted by a cartilaginous pad. The phalanges belonging to Digits III and IV have been lost, so that their formula can not be determined from this specimen. The gradation in size of the metacarpals from I to IV as well as the mesial inclination of the distal axes of I and II offers further evidence that Marsh was right in placing the larger unguals on the first digits in this genus.

An incomplete foot (Pl. XLI, Fig. 2), found by the writer in position, confirms the structure of Digit I. This specimen belongs to a smaller and more slender species than the last described and in the metacarpal region is very similar to the American Museum specimen before cited. The carpals and metacarpals were preserved in their normal positions with Digit I complete and closely connected. The first phalanges of Digits II and III were also in position; those of IV and V were exposed and had been displaced. In this specimen, as in Mus. No. 6668, Digit I is the strongest of the series and is armed with a stout claw. Phalanx 1 of this digit has the same angular form common to this bone in both the front and hind feet of Sauropoda. Its close articulation with the carpal by a well-marked concave surface, together with the stout ungual which it bears, indicates the important function laid upon this digit. The digit as a whole was directed inward and forward, showing no indication of having been opposable, as in the larger form.

The metacarpals grade evenly in size from the first to the fourth; the fifth is about as strong as the second. In length there is a noticeable tendency toward symmetry in the series. The first and fifth are nearly equal, as are the second and third; the fourth is intermediate. On the postero-lateral angle of Metacarpal II there is a strong process for ligamentary attachment. The first phalanges of Digits II and III are compressed vertically and laterally constricted at the middle. There is nothing in the structure of this foot to warrant placing it in the genus *Morosaurus* save its similarity to the foot of the American Museum specimen No. 332, which is associated with a scapula of the Morosaur type. From foot structure alone it could

scarcely be included in the same genus with the larger species just described.

The scapula and coracoid of No. 6668 are firmly coössified, as is true of the two other specimens of this genus which will be noticed. Compared with *Morosaurus grandis*, Marsh, the scapula as a whole is a little larger and the neck slightly longer in proportion. The coracoid is somewhat larger owing to the ossification of the connecting cartilage.

The humerus is a little shorter in proportion to the scapula and fore-arm and the deltoid crest is more prominent than shown in the type. However, the two bones are crushed in different directions, which probably accounts for apparent differences. The ulna is stout at the proximal end and deeply concave on the anterior surface to receive the radius. It is stronger in the shaft than the latter, but tapers so that the distal ends are about equal in size. The radius is nearly uniform in the shaft; the proximal end is more rounded and but little larger than the distal end. The radius crosses from the front to the side of the ulna; its angular surface admits of little or no rotary motion.

Following are a series of measurements of the fore leg of Museum specimen No. 6668 compared with measurements made by the writer from the type specimen of *M. grandis* preserved in the Museum of Yale University:

	No. 6668. M.	Type, <i>M. grandis</i> . M.
Coraco-scapula, total length with curve,	1.575	....
Scapula, total length with curve,	1.215	1.093
Scapula, length of upper end from concave border of blade, . . . . .	.665	....
Scapula, greatest breadth of blade, . . . . .	.590	.635
Scapula, greatest breadth of upper end, . . . . .	.384	....
Scapula, least breadth at constriction, . . . . .	.190	....
Coracoid, greatest breadth, . . . . .	.535	....
Coracoid, breadth from suture to inferior border, . . . . .	.330	....
Humerus, length, . . . . .	.970	.864
Humerus, breadth at proximal end, . . . . .	.390	.381
Humerus, breadth at distal end, . . . . .	.285	.260
Humerus, breadth of shaft at middle, . . . . .	.135	.127
Humerus, distal end to inferior margin of deltoid crest, . . . . .	.485	....
Ulna, length, . . . . .	.705	.628
Ulna, greatest breadth proximal end, . . . . .	.242	....
Ulna, greatest breadth distal end, . . . . .	.137	....
Radius, length, . . . . .	.665	....
Metacarpal I, length, . . . . .	.207	....
Metacarpal II, length, . . . . .	.243	....
Metacarpal V, length, . . . . .	.228	....
Ungual, Digit I, length, . . . . .	.188	....

Measurements of foot, Mus. No. 6641, compared with published measurements of the American Museum specimen No. 332 are as follows:

	No. 6641. M.	Am. Mus. No. 332. M.
Length of Metacarpal I,	.250	.205
Length of Metacarpal II,	.288	.250
Length of Metacarpal III,	.285	.250
Length of Metacarpal IV,	.260	.235
Length of Metacarpal V,	.245	.205
Length of Ungual, Digit I,	.140	....

A second coraco-scapula of considerably smaller size is even more distinctly of the Morosaur type (Pl. XLII, Fig. 1). It was also collected by the Museum Expedition of 1900 from the upper Como beds of the Grand River Valley, but came from a horizon fully one hundred feet above that of No. 6668. The specimen is splendidly preserved, as the photograph shows, and is complete in outline save a small portion of the upper end, which was distorted by crushing. The two bones are firmly ankylosed at the coraco-scapular suture and bear every evidence of having belonged to an animal fully adult. Its form as well as that of associated vertebræ at once identifies it with *M. grandis*.

The blade of the scapula is somewhat broader in proportion and the neck shorter than that of the type specimen. The superior margin of the blade is produced into a hook so thin as to be usually broken away and lost, but it has been observed in other well-preserved specimens. The postero-inferior border at the constriction is likewise produced into a thin prominence. The coracoid is proportionately larger and its junction with the scapula is marked by only a slight indentation in the superior border. The opening of the foramen on the lateral surface is directed downward in line with the scapular axis. An anterior view (Pl. XLII, Fig. 2) shows the natural curve of the scapula as well as that of the coracoid. The curve formed by their junction has been much reduced by crushing, as the opening of the suture on the mesial surface shows. A fine series of cervical and dorsal vertebræ, belonging to this specimen but still in the matrix, may add important data to our knowledge of the vertebral column in this genus.

Measurements of coraco-scapula, No. 6670:

	M.
Coraco-scapula, total length with curve,	1.405
Scapula, length with curve,	1.045
Scapula, greatest breadth of blade,	.625

	M.
Scapula, greatest breadth of upper end, . . . . .	.855
Scapula, least breadth at constriction, . . . . .	.185
Coracoid, greatest breadth, . . . . .	.432
Coracoid, breadth from suture to inferior border, . . . . .	.343

A much larger species of *Morosaurus* is represented by a well preserved coraco-scapula, a tibia, an ilium and a number of caudal vertebrae in the Museum collection, and a femur and fibula, in the collections of Kansas University, all from the Freeze-out Hills of Wyoming. The scapula and coracoid are firmly coössified (Pl. XLII, Fig. 3). The former is longer in proportion to its breadth than any other specimen of this genus examined. In outline the blade is rounded at the antero-superior border and with the coracoid forms a deep notch at the suture. The coracoid is likewise rounded in outline from the suture to the lip of the glenoid cavity and is deeply concave on the mesial surface.

Owing to the fact that this specimen was found in a general deposit where members of several species were heterogeneously associated, it is impossible to determine all of the parts belonging to this individual. The parts of the front and hind legs known show that they belonged to an animal much larger than any Morosaur yet described. But as it is not desirable to further encumber the literature with useless synonyms, this specimen will be provisionally referred to *M. robustus*.

It is noticeable in the coraco-scapulæ of this genus that the smaller adult specimens are broader in proportion and have their upper ends less produced. With regard to these proportions, it may be said that they grade quite evenly from the smallest to the largest specimen described. It is also worthy of note that of the three coraco-scapulæ figured, all are coössified. While this cannot be regarded as indicating anything more than adult age, it does indicate that coössification of the scapula and coracoid is common in the adult of this genus. A considerable variation in the outlines of the two bones in the region of the articulating border may thus be accounted for. In the young animal the coracoid is rounded at the angles; with the ossification of the connecting cartilage these fill in until there is but little indentation of the blade at the sutural line. By this process the coracoid not only increases in size, but the antero-superior angle becomes more produced.

NOTE ON THE GENUS CAMAROSAURUS, COPE.

While examining the type specimen of *Camarosaurus* at the American Museum, through the kindness of Dr. Osborn, the writer was struck by the similarity of its pectoral girdle to that of *Morosaurus*. This similarity is especially noticeable between the large coraco-scapula (Mus. No. 6285) and Cope's type as figured in Pl. XLII. The presence of but four coössified centra in the sacrum offers a further basis of correlation. The gap between the two forms, in point of size, is now partially bridged by the large specimen just referred to, *M. robustus*. *Camarosaurus* may thus prove to be the extreme type of development in this phylum; if not, as Dr. Osborn has suggested,* a member of that genus.

However, it is probable that *Atlantosaurus*, Marsh, is more nearly related to this genus than is *Morosaurus*. The types of both come from the same locality at Cañon City and from nearly the same horizon. Their size, as represented by the length of the femora, is essentially the same. Each has four coössified centra in the sacrum; those of the Cope specimen are described as solid, while the New Haven specimen is nearly so. A third sacrum in the collection of this Museum, provisionally referred to *Atlantosaurus*,† has the same vertebral formula, is similar in relative size and has only very small cavities in the centra. The coracoid of the Museum specimen is similar to that of the type, though slightly larger, as is the specimen throughout. The characters of the first caudal, especially the short blunt diapophyses, are characteristic of both. In his original description Cope predicted the unusually long humerus which the Museum specimen has so well demonstrated. The three specimens may thus be regarded as representatives of a single genus, which, in view of its priority, should retain the generic name *Camarosaurus*. The description of the type specimen promised by Dr. Osborn will doubtless throw further light upon the relationship of this interesting group.

* Bull., Am. Mus., Vol. XIV, p. 200.

† Science, April 5, 1901.